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KEIGLEY BRANCH BRIDGE
Iowa Bridges Recording Project
Spanning Keigley Branch at
county road, 3 miles Northeast
of Gilbert
Gilbert Vicinity
Story County
Iowa

HAER No. IA-74

BLACK & WHITE PHOTOGRAPHS

WRITTEN HISTORICAL & DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Department of the Interior
P.O. Box 37127
Washington, D.C. 20013-7127

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KEIGLEY BRANCH BRIDGE

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Location: Spanning Keigley Branch at county road,
3 miles northeast of Gilbert, Story
County, Iowa.
UTM: 15.450350.4664940
USGS: Ames East, Iowa quadrangle
(7.5 minute series, 1991)

Date of Construction: 1913

Designer: Iowa State Highway Commission

Contractor: Koss Construction

Present Use: Roadway Bridge

Significance: Although the arch was not the preferred
bridge type of the Iowa State Highway
Commission, state engineers designed
several reinforced concrete arches
during the 1910s. The Keigley Branch
Bridge, constructed in 1913, was one of
their earliest designs. With sturdy
proportions and generous wingwalls, its
plan incorporated many of the features
they believed private bridge designers
neglected in order to spare expense.
Conveniently located on the old Des
Moines-Minneapolis Highway not far from
the college town of Ames, the Keigley
Branch Bridge served for many years as
the Highway Commission's model arch.

Historian: Juliet Landler, engineer, August 1995

Project Information: This document was prepared as part of
the Iowa Historic Bridges Recording
Project during the summer of 1995 by the
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(HAER). The project was sponsored by the
Iowa Department of Transportation
(IDOT). Preliminary research on this
bridge was performed by Clayton B.
Fraser of Fraserdesign, Loveland, CO.

Nestled between farms in Story County, Keigley Branch Bridge carries an unpaved country road over a stream that gives its name. With its plain design, unspectacular 45 foot span, and inconspicuous bucolic setting, this unassuming structure certainly belies its historical significance. Built in 1913, the Keigley Branch Bridge served for many years as the prototypical reinforced-concrete arch in Iowa State Highway Commission's campaign for permanent structures. In the twenty years following its construction, many similar arches were built across the state. Despite its widespread popularity and aesthetic appeal, the reinforced-concrete arch never became a design the state engineers aggressively promoted. In fact, quite the contrary is true. Much of the early existence of the State Highway Commission was marked by a vicious battle against monopolistic bridge builders in which the state engineers denounced the arch form as unsuited to Iowa soils.

From its conception, controversy surrounded the Iowa State Highway Commission. The idea of placing a state highway department at the State College in Ames probably emerged sometime around 1902. Supporters of the plan argued that a union with the engineering division which was highly acclaimed for its work in road and bridge construction technology would be undoubtedly profitable for the state. However, many rural citizens, fearful of losing their local power, insisted that another bureaucratic organization would be an unnecessary waste of taxpayer money.¹ A compromise between the two sides was struck in 1904. Representative F.F. Jones of Montgomery County proposed to the General Assembly a bill stating the "Iowa State College, at Ames, shall act as a highway commission," receiving funding from the school's normal budget for experimental purposes.²

The legislation passed and Iowa State Board of Trustees appointed Anson Marston, Dean of Engineering, and C.F. Curtis, Dean of Agriculture, as commissioners of the department, and Thomas H. MacDonald, a recent graduate of the civil engineering program, as their full-time assistant and field engineer. The Highway Commission's official duties included: (1) experimentation in new systems of highway construction and maintenance, (2) dissemination of information on highway improvements, construction, and maintenance to county supervisors and other

¹Powers, Samuel C.E. "Iowa State Highway Commission." *Iowa Journal of History and Politics*. Vol. 29, No. 1. January 1931. 42.

²Iowa Department of Transportation. *75 Years on the Move!*

highway officers through demonstrations, (3) formulation of advisory rules and regulations for the repair and maintenance of highways, and (4) submittal of an annual report to the governor.³ The Iowa State Highway Commission began operations by investigating existing bridge and road construction practices in several counties in different parts of the state. Their research revealed that the repairs and replacement of culverts and wood or light steel bridges consumed all the counties' bridge funds and from 30% to 60% of their road funds. Immediately the Highway Commission initiated a movement for the construction of more permanent structures.

Around the turn of the century, reinforced concrete was still a relatively new construction material in the United States. Fritz von Emperger, an Austrian engineer, designed a concrete arch with steel I-beam embedded for the town of Rock Rapids in Northwest Iowa, but after it was built in 1894, no other reinforced-concrete bridges were constructed in Iowa until after 1900.⁴ Around this time Iowa State's Engineering Department had conducted several tests on reinforced-concrete slabs, beams, and small arches built using a system of reinforcement with rods, based on a 1867 patent of Frenchman Joseph Monier. From these experiments, the state engineer concluded that flat slabs and girder structures were the most appropriate bridge types for Iowa's rural conditions and issued standard plans for their construction beginning in 1904.⁵ The Highway Commission also built several demonstration models in various parts of the state.⁶

Once the Iowa State Highway Commission's campaign for permanent concrete slabs and girders was underway, Indianapolis engineer and businessman Daniel Luten began promoting his plans in Iowa for another bridge type - the reinforced-concrete arch, hailing it as the "ideal highway bridge." According to Luten, such a

³Powers. 43.

⁴The Rock Rapid arch, named the Melan Bridge after the inventor of its patented reinforcement system, was the first bridge constructed using this novel technique and is described fully in HAER report IA-15.

⁵MacDonald, Thos. H. "Bridge Patent Litigation in Iowa." *The Iowa Engineer*. Vol. 18, No. 4. January 1918. 118.

⁶Ibid. 118.

bridge type displayed most ably the following characteristics:⁷

1. Permanence
2. Artistic appearance
3. Increasing of strength
4. Safety
5. Stability in flood conditions
6. Effective waterway opening
7. Efficient use of materials
8. Employment of home labor and materials
9. Providing continuous roadway
10. Ability to be easily widened
11. Ability to be easily modified or upgraded
12. Simplicity in design and erection

He was a convincing salesman, and by 1918 he had nearly 100 contracting agents operating coast to coast. Over 9,000 Luten bridges had been constructed nationwide; over 700 in Iowa alone.⁸

When Luten's agents began building concrete-arch bridges in Iowa in 1906, the Highway Commission objected. Not only did his operation stifle their efforts to standardize bridge construction statewide, but Luten was rewarded with vast sums of Iowa money in the form of royalty payments. Moreover, they contended that his bridge designs and construction methods were unoriginal, and thus his patents were invalid. The Highway Commission also denounced his skill as an engineer, claiming that his reinforced arches were hazardous to the public. His agents were attacked with accusations of bid rigging and other illegal activities. A twelve-year battle between Luten and the Iowa State Highway Commission ensued. In 1918 Thomas MacDonald, in an article for the college's engineering journal, defended the Highway Commission's position,

"Probably ninety percent of bridges built on the Luten patented designs in Iowa were privately let without other plans or other competitions being considered. In fact, in some cases there was not even a written contract covering the transaction. After investigating the type of bridges that were being built under the plan, the Highway Commission refused to approve the construction without decided modifications, which

⁷Luten. "Arch Design; Specialization and Patents" *Journal of the Western Society of Engineers*. September, 1912, 577-603.

⁸Luten, "What's Wrong with Iowa?" *Engineering and Cement World*, May 15, 1910, p. 20.

required heavier sections of concrete and greater areas of steel."⁹

In the Highway Commission's early years, no state plans for concrete arch construction were issued.

During its first decade, the Highway Commission's lack of authority over county officials hampered its progress, and Iowa's roads and bridges showed little improvement. Years later Luten did not fail to point out that Iowa's surfaced roads decreased from 2% in 1909 to one-half of 1% in 1914. He alleged that the Iowa State Highway Commission, "in its efforts to establish itself and the college as the dictators of road policy," was entirely responsible for this decline.¹⁰ This was a difficult time for the Highway Commission. Rural communities still were suspect of the fledgling organization, making its mission often impossible and threatening its longevity.

Conditions began to improve in 1913 when the General Assembly passed an act which reorganized the Highway Commission, separating it from the college and giving it increased powers. Its revised duties included:

1. To devise and adopt plans of highway construction and maintenance suited to the needs of the different counties of the state, and furnish standard plans to the counties in accordance therewith.
2. To disseminate information and instruction to county supervisors and other highway officers, answer inquiries and advise such supervisors and officers on questions pertaining to highway improvements, construction, and maintenance and of reasonable prices for materials and construction.
3. To keep a record of all important operations of the highway commission and to annually report the same to the governor by the first day of December, report shall be printed as a public document.
4. To appoint such assistants as are necessary to carry on the work of the commission, define the duties and fix the compensation of each, and terminate at will the terms of employment of all employees; provide for necessary bonds and fix the amount of the same.

⁹Ibid. 120.

¹⁰Luten. "What's Wrong with Iowa?" *Engineering and Cement*

5. To make investigation as to conditions in any county and to report any violation of duty, either of commission or omission, to the attorney general, who shall take such steps as are deemed advisable by him to correct the same.

6. The state highway commission shall have general supervision of the various county and township officers named in this act in the performance of the duties here enjoined, and shall have full power and authority to enforce the provisions of this act.

7. To perform all other duties required by law.¹¹

Eight percent of the automobile registration fees collected by the state were allocated to the new Highway commission as a maintenance fund. In addition, the law mandated that local officials seek the state engineer's approval on any construction projects with estimates over \$2,000. Each county also was required to hire its own qualified engineer to oversee road construction.¹²

That year the highway department increased its permanent staff to eight, adding four new engineers: J.E. Kirkham, Consulting Bridge Engineer; C.B. McCullough, F.R. White, and J.H. Ames, Assistant Engineers. T.H. MacDonald was given the title of Highway Engineer, a position he maintained until becoming Director of the U.S. Bureau of Public Roads in 1919.¹³

Of all the members of the Highway Commission, MacDonald was strongest in his disapproval of the concrete-arch bridge form. In a 1911 article, he wrote:

The ancients have a saying that the "arch never sleeps." In this type of construction, more than any

¹¹Laws of Iowa, 1913, Ch. 122, Sec. 3, as reprinted in Powers. 45-46.

¹²Powers. 46.

¹³Thompson, William H. *Transportation in Iowa: A Historical Summary*. Iowa Department of Transportation, 1988. 57

other, the forces of nature, and more particularly the temperature changes, are everlasting at work tending to destroy.¹⁴

Since an arch requires strong foundations, MacDonald believed that form was particularly unsuited to Iowa's soils which were prone to settlement.

In the Highway Commission's annual report for 1913, the state engineers included a chapter on the merits of bridge standardization. They wrote that because Iowa was divided into three distinct topographical and geological regions, three different approaches to bridge building were necessary. The Kansan drift region, which covers the entire southern half and parts of western Iowa, was distinguished by sharply defined ravines and a scarcity of concrete materials. Thus for this area, they recommended a deck girder design which was relatively light requiring less hauling of materials, but also which was heavily reinforced. Shallow channels and frequent high waters characterize the Iowa drift region which occupies the central eastern part of the state. To the west lays the slightly larger Wisconsin drift sheet, youngest of all the regions. With broad flat valleys and sandy clay soils which are difficult to drain, this area is also plagued by flooding. However, plentiful deposits of sand and gravel also occur. For these two regions, the Highway Commission suggested slab or thru-girder bridge types since they provided the most headroom and greatest waterways.¹⁵

While engineer C.B. McCullough was working for the Highway Commission, he was pursuing simultaneously a C.E. degree at Iowa State College. For his thesis, he expanded upon the subject of highway bridge standardization.¹⁶ He reviewed the most commonly used bridge types, assembling standard designs for concrete slab, through girder, and deck girder constructions since these were the plans the Iowa State Highway Commission typically issued. Absent from his report was a standard design for reinforced-

¹⁴From Wallaces Farmer, March 24, 1911, as cited by Daniel Luten. "What's wrong with Iowa?" *Engineering and Cement World*. May 15, 1918. 24-31. 27.

¹⁵Iowa State Highway Commission, Annual Report for 1913. 195-196.

¹⁶McCullough, C.B. "Standardization of Highway Bridge Practice." G. E. Thoenig, Iowa State College, May 1916. 1-22.

concrete arch bridges, although he did include a short discussion about the arch form. McCullough listed three advantages:¹⁷

1. Its beauty of line and great variety of architectural expression possible.
2. The fact that live loading stress (except in open spandrel construction) is a very small percentage of the total stress thus minimizing the danger of serious over-stress from increased traffic loadings.
3. The ease with which the type may be widened to accommodate future need.

However, he also mentioned its serious drawbacks:¹⁸

1. The high cost of form work and centering, the difficulty of placing and holding the reinforcement and the difficulty in holding the concrete on the steep incline at the haunch necessitating in many cases, back forms, which are expensive.
2. That uneven foundation settlement or a slight spreading of the abutments may seriously overstress the superstructure.

McCullough noted that the last point was "most important in view of the amazing number of light arches which have been badly cracked and in many cases totally failed from this cause."¹⁹ He attached a picture of a collapsed Luten bridge.

When Luten filed suit against Marsh Engineering Company of Des Moines for patent infringement in 1912, the state stepped in to take the defendant's side in an attempt to end the era of patented-bridge construction in Iowa. Ironically, the bridge upon which this case hinged had been built in Albert Lea, Minnesota. The Highway Commission, however, had advised the General Assembly to pass a law which entitled the governor to appoint the Attorney General to the defense when such suits were brought against municipalities or contractors of the state.²⁰ In turn the Highway Commission engineers became involved in the case

¹⁷Ibid. 18.

¹⁸Ibid. 19.

¹⁹Ibid.

²⁰Letter "What's Wrong with Iowa?" 22

when the Governor asked them to aid the defense by assembling evidence against Luten. McCullough was given the task of compiling a history of the evolution of reinforced-concrete and concrete arch technology, and in the process became an authority on this bridge type.²¹ Later, he would design some of the country's most spectacular long-span concrete arches in Oregon during the 1930s.

Although all records state that the Iowa State Highway Commission designed Keigley Branch Bridge in 1913, this is probably one of McCullough's earliest structures. Such a project would have fallen under his jurisdiction since that year he had direct charge of the Highway Commission's concrete bridge design and headed the Designing Department.²² The bridge receives little mention in the Highway Commission's 1913 Annual Report, but a photo of it appears with the caption,

"SPECIAL DESIGN CONCRETE ARCH - This is a 45' span with a 20' roadway built on the Des Moines, Mason City and Minneapolis Highway, three miles northeast of Gilbert, Story County, in 1913. It cost \$3,384.85."

The Keigley Branch Bridge was built to be a model arch bridge. The design, with its elliptical shape and bundled reinforcement, resembled a Luten arch in many ways. Of course, there were some differences. The guardrails were Iowa State Highway Commission standard design with rectangular panels. The dimensions were somewhat stockier which also was becoming a signature for the Highway Commission.

Against allegations of wastefulness, McCullough defended the state's design philosophy in an article entitled "Are the Highway Commission Bridges Too Heavy?"²³ He wrote, "if the structures designed under specifications lighter than the state standard minimum prove to be adequate both as regards safety and permanence, then the excess material is not justifiable." After examining the condition of 82 thin-section bridges built under county supervision and finding 60 defective, he was confident the

²¹This report was submitted undated, and is part of the Iowa State attorney General's file for the case which lasted from 1912 to 1918.

²²Iowa State Highway Commission. First Annual Report for the Year 1913. 21.

²³McCullough, C.B. "Are the Highway Commission Bridges Too Heavy?" Iowa Highway Commission Service Bulletin. No. 12. December 1914. 2, 6.

KEIGLEY BRANCH BRIDGE
HAER No. IA-74
(Page 10)

Highway Commission standards were "not only warranted but absolutely essential." These standards which included specifications for 4 foot deep foundations, thick sections, generous wingwalls, and wide roadways, were adhered to in the construction of Keigley Branch Bridge, and probably account for its near perfect condition 82 years later.

The Des Moines-Mason City-Minneapolis Highway was moved a few miles east of the Keigley Branch Bridge years ago, and today the bridge carries little traffic. In its first years of existence, however, the bridge held a strategic location on the significant thoroughfare, not far from Iowa State College or the office of the newly formed Iowa State Highway Commission, and was seen by many. Although the Highway Commission maintained that the arch bridge type rarely was an efficient or economic solution, the Keigley Branch Bridge served many years as a fine example of state standardized construction methods of an alternative bridge form.

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ADDENDUM TO
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HAER No. IA-74
(Page 13)

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This appendix is an addendum to a 12-page report previously transmitted to the Library of Congress.

APPENDIX: ADDITIONAL REFERENCES

Interested readers may consult the Historical Overview of Iowa Bridges, HAER No. IA-88: "This historical overview of bridges in Iowa was prepared as part of Iowa Historic Bridges Recording Project - I and II, conducted during the summers of 1995 and 1996 by the Historic American Engineering Record (HAER). The purpose of the overview was to provide a unified historical context for the bridges involved in the recording projects."